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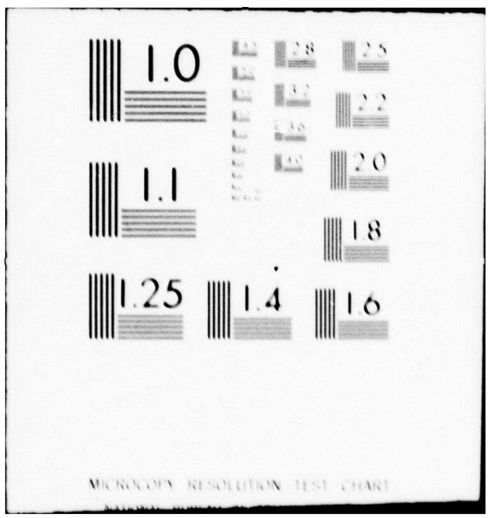
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ORDER AND SHIP TIME COMPUTATION FOR STOCKED LOCAL PURCHASE ITEMS

Douglas J. Blazer, Captain, USAF
Cecil J. Carter, GS-13

LSSR 26-78B

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The current Air Force method for computing the Order and Ship Time (O & ST) for Local Purchase (LP) items is to determine an overall average for all requisitions not exceeding 175 percent of the Uniform Material Movement and Issue Priority System (UMMIPS) standard. With data collected from nine Air Force bases, three analyses were conducted; the result of which indicated that the currently computed O & ST average does not provide an accurate O & ST on which to base stock leveling decisions. The first analysis indicated that there were three factors affecting O & ST: the method of procurement, commodity group of the item, and the characteristics of the individual item. These factors were then used to develop alternative computational models for O & ST. The second analysis compared these models to determine which model provided the most accurate O & ST forecast. A final analysis was then conducted on the effect of the truncated O & ST values exceeding 175 percent of the UMMIPS standards. Conclusion and recommendations were drawn from the analysis of alternative computational models and the analysis of the 175 percent truncation policy.

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has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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CHAPTER I

INTRODUCTION

Overview

The Air Force Standard Base Supply System (SBSS) is designed to aid retail-level managers in the control of supplies and equipment at over 120 installations world-wide. The SBSS is an inventory control system which is based on inventory management and statistical analysis techniques. The large majority of items, over $12.4 billion (12:1) stored and distributed by Base Supply functions, are centrally procured; however, a significant amount, over $2.6 billion (12:1) are locally procured. Local Purchase (LP) is defined as "a method of obtaining supplies and equipment wherein item management is decentralized within the AF logistics system [17:8-3]." It includes those items for which the material manager has "prescribed local management and procurement by AF bases . . . [18:8-3]." Thus, Local Purchase items are those items obtained by the base-level Procurement Office.

The Air Force inventory system is based on an inventory or stock control system, whose main purpose is "to provide the most effective support from the least system resources [18:11-1]." The stock control system determines

optimum levels for on-hand inventory and develops reorder point levels to insure stock is on hand for its intended use. As a corollary of the objective to achieve the most support at least cost, it is imperative to maintain a relatively low investment in inventory. Thus, the reorder level should include only those resources required for the next demand period. The concept used to develop this optimum reorder amount is called economic order quantity (EOQ)*. For the purpose of this thesis, the discussion of Order and Shipping Time (O&ST) is restricted to stocked items. Economic order quantity items comprise the bulk of stocked items, with such things as repair cycle items and hand tools comprising the bulk of the remaining stocked items.

Of the $12.4 billion of retail inventory in the Air Force, over $296.0 million (14) worth of items are governed by the economic order quantity concept. The EOQ "is based on an economic order policy that balances the cost to order with the cost to hold [18:11-7]." Along with the economic order quantity there are two other factors which are considered to determine the optimum demand level and reorder points: they are the order and shipping time quantity (O & STQ), and the safety level quantity (SLQ). The order

*Economic order quantity (EOQ) is both a reorder concept and a term used to describe items that are managed under that concept. Thus, EOQ also refers to inventory replenishment items in the Air Force. Ninety-five percent of LP transactions involve EOQ type items; however, only 11 percent of the total LP dollars are EOQ (12:1).

and ship time quantity is defined as the quantity required during "the average elapsed time in days, between the initiation and receipt of stock replenishment requisitions [18:11-8]." The SLQ is the quantity of material required to be "held for protection against emergencies, and is not used in production as long as daily usage and order lead time are completely predictable [7:205]." The safety level quantity is a factor of the O & STQ as shown in this formula (18:11-2): $SLQ = \sqrt{3(O\&ST)}$. The formula using all three of these factors is (18:11-2):

$$\text{Demand Level} = EOQ + SLQ + O \,\&\, STQ$$

Although all three factors, EOQ, SLQ, and O & STQ, are used in the computation of demand levels, this thesis addresses only O & ST. The SBSS collects O & ST data at each base by source of supply. Thus, the O & ST for LP items is the average amount of days to receive an item procured by the Base Procurement Office. The computation of O & ST for local purchase items is an important factor to the Air Force in terms of both dollars and mission effectiveness. If the O & ST is computed incorrectly or based on erroneous data, the demand level will not be properly determined. This discrepancy will cause either too much stock and increased cost or too little stock and decreased mission support effectiveness. Thus, significant problems can exist if the O & ST is not computed correctly.

Unfortunately, problems do exist with the computation of O & ST for local purchase items. A representative of the Deputy Chief of Staff for Installations and Logistics on the Air Staff has stated:

> Order and Ship Time for local purchase items has been a persistent problem in the United States Air Force Supply System since the inception of the Standard Base Supply System. The problem has been addressed sub-optimally in the past by technical experts without the benefit of empirical data or the use of a systems approach to generate an optimal solution [9].

Statement of Problem

The problem addressed by this thesis was to identify deficiencies in the current Air Force method to compute Order and Ship Time for Local Purchase items, to identify factors having a significant effect on O & ST, and to develop a more accurate method to compute O & ST for Local Purchase items. The term "more accurate" was defined as closer in value to the average O & ST for the individual item being measured.

Objectives

The specific objectives of this thesis research were:

1. To develop a mathematical model for the computation of O & ST for LP items in order

   a. to verify that a problem existed with the current method,

b. to identify factors that significantly influence O & ST, and

c. to evaluate results obtained from alternative methods of computing O & ST; and

2. To develop a more accurate method of computing O & ST for LP items.

Research Question/Hypotheses

The following hypotheses have been empirically tested:

1. The current system does not accurately compute the O & ST for LP items.

2. A number of factors significantly influence O & ST for LP items. The following factors were considered:

a. The homogeneous grouping of the items.

b. The method of procurement.

c. The individual item procured.

3. A computational method, using a factor or combination of factors, was developed which provides a more accurate prediction of O & ST.

4. The current policy of truncating all values of O & ST that exceed 175 percent of the Uniform Material Movement and Issue Priority System (UMMIPS), significantly detracts the supply support effectiveness of local purchase items.

The following research question has been addressed:

1. How can the factors identified as most relevant in paragraph 2 above be used to compute a more accurate O & ST?

CHAPTER II

LITERATURE REVIEW

Introduction

Before developing alternative methods, it is important for the reader to understand the current system and some of the factors influencing the system. Consequently, this chapter addresses the following main points: current system, significant influencing factors, and justification for this study. A study of these areas provides the basis necessary for developing better computational methods for predicting O & ST.

Current System

There are currently a number of problems associated with computing the O & ST for local purchase items. These problems are: (1) failure to consider a number of factors which affect O & ST for LP items, (2) procedural differences between the Supply and Procurement functional areas, and (3) the technique for eliminating orders with extreme O & ST totals from computation of an average O & ST. To understand these problems, current policies and procedures were analyzed in both the Supply and Procurement functional areas since O & ST for local purchase items relates to both

activities. The discussion begins with a more detailed explanation of O & ST. Next, some areas of policy conflict between the Supply and Procurement functional areas were documented; and finally, a current computational method (175 percent truncation) was highlighted.

Order and Ship Time Computation

The Order and Ship Time quantity is the numerical value associated with the level of parts required to compensate for usage of the part during the time the item is on order (from initiation of the requisition to receipt of the part in Base Supply) (18:11-8). The formula used is (18:11-8):

$$\text{O \& STQ} = \text{O \& ST} \times \text{Daily Demand Rate (DDR)}^{*}$$

The O & STQ is an extremely important factor since it determines the point to reorder the stock. Basically, the reorder point is the sum of the SLQ, which is a factor of O & STQ using the formula $\text{SLQ} = \sqrt{3 \times \text{O \& STQ}}$, and O & STQ (18:pp.6-16 to 6-17). Thus, stock is reordered at point 1 in the diagram below so that theoretically the level on

*The Daily Demand Rate is the quantity of items required daily based on historical data (18:11-2).

hand will be consumed down to the safety level quantity simultaneously with receipt of the new stock (at point 2).*

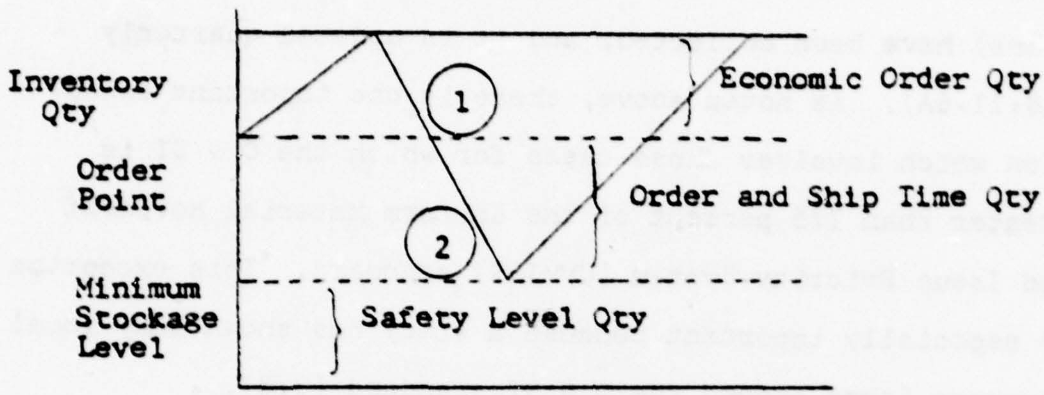

Figure 1. Ideal Inventory Movement (7:215)

Air Force policy states that "the actual O & ST will be used in computing levels . . . excluding those receipts . . . [whose O & ST] tend to distort the computation [18:11-5]." Thus, the actual number of O & ST days (with one exception) is collected at each Air Force base and stored in a routing identifier record**. A routing identifier is a code that corresponds to a particular source of supply. O & ST, then, is collected and consolidated to a particular source of supply. Thus, for all LP

---

*Figure 1 depicts the Air Force concept of EOQ, which does not exactly coincide with commonly held view of civilian industry. In academic and civilian usage, EOQ consists of both O & ST quantity and the inventory quantity.

**Since this thesis deals exclusively with local purchase items, the only routing identifier code addressed is JBB. (JBB is a computer code referring to the base-level procurement office as the source of supply.)

items, the O & ST data are consolidated and averaged, since they are considered one source of supply. The O & ST is computed as soon as sufficient data (at least 100 observations) have been collected, and it is updated quarterly (18:11-6A). As noted above, there is one important exception which involves those cases for which the O & ST is greater than 175 percent of the Uniform Material Movement and Issue Priority System (UMMIPS) standard. This exception is especially important because a study has shown many local purchase items exceed the O & ST standard (3:8).

Policy Conflict Between Supply and Procurement

Prior to discussing the 175 percent truncation effect on O & ST, it is important to understand the problems associated with the standard with which the truncation deals. Since O & ST for LP items involves an interface between Supply and Procurement, it is important to examine any interface problems between the two functional areas. More specifically, there exists a conflict in the standards for O & ST between Supply and Procurement. The first conflict deals with the definition of O & ST. The Procurement functional area deals with the Procurement Administrative Lead Time (PALT), which measures ". . . time from receipt of the purchase request until the date of award less time the purchase request was returned for additional information [16:1-9]." The table below indicates the

standards for Procurement (16:109) and Supply (18:11). It should be noted that PALT is only a component of the total O & ST and that PALT excludes some time that is included in the AFM 67-1 definition. Specifically, PALT ends at contract award, not upon delivery of the item. Also, PALT does not include administrative time the order has taken in Base Supply, either initially to prepare the purchase request or any time taken when the purchase request was returned for additional information. Thus, for routine items (priority 09-15), which comprise the bulk of local purchase requests (14), the UMMIPS standard of 45 days is just about completely expended in administrative time. As noted earlier, those items where the O & ST exceeds the 175 percent standard are not included in the computation of O & ST.

Table 1

Standards for LP Order and Ship Time
(16:1-9; 18:11 Attach 17B)

UMMIPS Priority	Procurement AFM 70-332 Standard in Days	Supply (UMMIPS) AFM 67-1 Standard in Days	175 Percent of AFM 67-1 (UMMIPS) Standard in Days
01-03	3	12	21
04-08	9	18	32
09-15	40	45	79

Truncation Computational Methodology

Since the 175 percent truncation has a significant bearing on the problem, it was considered further. The 175 percent truncation is based on a statistical standard developed in an Air Force Data Systems Design Center (AFDSDC) study in 1969. The 175 percent was developed based on including 80 percent of the samples of computed O & ST. The study stated, ". . . 80 percent [of the samples] should be used . . . to have confidence that the average computed uses 'most' of the information and thereby describes that which is normal [11:1]." The study went on to say:

> Assuming a normal frequency distribution (after extremes have been eliminated) a small standard deviation indicates that most of the actual O & STs used fall close to the computed average [11:1].

This assumption normally holds for centrally procured items because the items are usually in stock or a ready source of supply already exists and is contracted. The order and ship time reflects just the administrative time of ordering, selecting the item from stock, packing, and shipping. However, as shown in an Edwards AFB study, where one-third of the items did not fall within 175 percent of the standard, this assumption does not necessarily hold for local purchase items (3:8).

Significant Influencing Factors

Several studies have indicated additional factors must be considered when dealing with local purchase items (3:4). First, there is a wide range of products and stock classes involved. Central depots usually deal with only certain stock classes and, therefore, items from the same or similar sources of supply. Thus, O & ST can be readily computed for that source of supply. However, when dealing with numerous stock classes and many different vendors, as is the case with LP items, it is more difficult to compute an average O & ST for that source of supply. Secondly, the variable effects of the purchase cycle, especially the procurement method and vendor availability, must be considered. Again, at a depot, sources of supply are fairly well determined and in many cases immediately available; however, for local purchase items this is not necessarily the case. Thus, considerable time can be expended in locating appropriate vendors for LP items. A third factor which can significantly affect O & ST is the individual item itself, especially if it is a first-time demand for an LP item. Considerable time is required to load item descriptive data in the Base Supply and Procurement systems. These additional factors are discussed in more detail below.

This thesis hypothesized that there was a correlation between homogeneous groupings of items and O & ST.

This hypothesis was supported by a 1975 study conducted by Purchasing magazine (6:73). Researchers from Purchasing magazine obtained monthly responses from over 400 civilian purchasing managers and submitted the responses for analysis to a panel of experts. The study used quantitative information collected from 11 major commodity groups* with 125 separate families. The table below presents some examples from a commodity group.

Table 2

Purchasing Lead Times (6:74)
(Percentage of stock received within O & ST)

Steel Group Families	1-5 Weeks	6-10 Weeks	11-20 Weeks	21-30 Weeks	Over 30 Weeks
Plate	34	22	36	4	4
Sheet & Strip	42	22	27	3	6
Strapping	83	14	3	0	0
Forgings	3	10	23	26	38

As indicated in the table, the majority (92 percent) of stock from the Plate family can be expected to be received from 1-20 weeks, while in the Forgings family only 36 percent can be reasonably expected to arrive before the 20th week. In the current Air Force system each item in the

*Commodity group would relate to a National Supply Group in the DoD and refers to a classification of like parts, for example, electronic parts.

entire family would have the same O & ST. Thus, the grouping of like items is a factor not considered by the current system.

Another major factor influencing O & ST is the method of procurement. Procurement procedures specify that when an order to replenish Base Supply stocks is received by Base Procurement it is assigned a 40-day Procurement Administrative Lead Time (PALT). This is the amount of time allowed the Contracting Officer from the date of receipt of the purchase request (supply requisition), until the contract award date (16:1-9). The PALT varies considerably depending on the method of procurement. Table 3 illustrates the differences in administrative lead time dependent on the method of procurement. As shown in the table, an item purchased through a delivery order would have a significantly shorter O & ST than an item procured by contract. However, under the current system both would have the same O & ST.

Table 3

Methods of Procurement (2)

Methods of Procurement	Estimated PALT in Days
Purchase Order	15-30
Delivery Order	1-10
Blanket Purchase Agreement	15-30
Contract	45-60
Automatic Purchase Order*	1-3

*Currently being tested at six CONUS bases. Will be implemented at all USAF bases 1 April 78.

There are other procurement related procedures which influence O & ST. However, these procedures were not analyzed in this thesis because they are relatively minor and there is no method in the current system to identify the requisition and thereby allow statistical analysis. These procedures are identified below and include the use of a hold-over file and use of an intermediate buyer.

An administrative procedure influencing the O & ST is the use of the hold-over file by the Base Procurement System. The hold-over file allows the Contracting Officer to hold selected low priority requisitions for the possibility of consolidation in order to increase the probability of receiving quantity discounts. The holding of requisitions will have an effect on the O & ST.

Another procurement procedure that may influence the Order and Ship Time is the possibility that the vendor that receives the contract may be an intermediate buyer. Should this occur, the administrative process of contract award is duplicated by the intermediate buyer (2) and thereby incurs a longer O & ST.

The characteristics of the individual item are another major factor that can significantly affect the computation of O & ST. A study to examine the lead time average for individual items was conducted by the U.S. Naval Supply Depot at Mechanicsburg, Pennsylvania. In this study, 5,000 items were examined and an average and a

frequency distribution were developed. The conclusion reached was that as the complexity of the item increased, there was an increase in O & ST (1:15). This Navy study would suggest that computation of O & ST by items would acknowledge the variances in complexity. This has also been proposed in a suggestion submitted to the Air Force Data Systems Design Center at Gunter AFS, Alabama, by Captain Robert W. Menestrina of Edwards AFB, California (3:10). As a supplemental part of this thesis, the AFDSDC requested Captain Menestrina's suggestion be evaluated for potential Air Force-wide use. The analysis and recommendations were documented in Chapters V and VI of this thesis.

Justification

A study was conducted which validated many of the problems inherent in computing the O & STQ for Local Purchase items. This study was conducted at Edwards AFB from 16 July 1976 to 16 November 1976. During this period actual O & ST was collected to compare to the levels computed in the supply system. The final report is quoted in part.

> A total of 4899 demands was received of which 1079 were UMMIPS priority 02-08 and 3820 were routine demands. In general, the JBB [local purchasing routing identifier] O & ST average was 60 days rather than 47 days currently calculated by the quarterly O & ST update routine. Statistical analysis also indicates a standard deviation of 30 days. Using these factors, it appears approximately 98% of all demands are delivered in less than 120 days [3:8].

The report also stated that approximately one-third of all demands were not included in the O & ST totals because they exceeded 175 percent of the standards (3:8).

Another factor highlighted by this study was the wide variance of O & ST depending on stock class. It was found that the O & ST for some stock classes was rarely within 175 percent of standard. The report went on to state:

> . . . [This] study has identified 34 Federal Stock Classes with over 20 demands . . . whose average lead times are over 60 days. In fact two of these classes, FSC 5995 and 5130, had an average lead time over 79 days. . . . In other words, the majority of demands for these two classes exceed the standard so greatly that they are not even included in building the lead time average [3:8].

An equally important point regarding the variance in O & ST among National* Supply Classes is that the O & ST is aggregated for all local purchase items into one O & STQ. Thus, the demand level for those items whose O & ST fell well within standards will be much higher than necessary and economically prudent.

For example, Table 4 provides a simplified model of the effect of using a gross average as opposed to using an average that was more representative of the actual O & ST for individual items. The table shows the comparison of

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*The term "National" has replaced the term "Federal" in the Air Force description of stock class/number terminology.

the computation of the Inventory Investment Cost for both the current system O & ST and a hypothetical, revised, more accurate O & ST. The formulas necessary for the computations shown in the table were obtained from the AF Supply Manual (18:11-2).

Table 4

Comparison of Inventory Investment Costs

Current System

O & ST	DDR	Unit Cost	Inventory Investment
10	1	$10	$100
10	1	4	40
10	1	1	10
			$150

Revised System

O & ST	DDR	Unit Cost	Inventory Investment
4	1	$10	$40
8	1	4	32
18	1	1	18
			$90

where: O & ST = Order & Ship Time
DDR = Daily Demand Rate
O & ST x DDR x Unit Cost = Inventory Investment Cost

In this example all items have a daily demand rate (DDR) of one to simplify the calculations. Using the revised system, the investment in inventory is reduced by $60.

The wide variance in the O & ST for LP items also affects supply customers. The estimated delivery date which is provided to the customers is based on the O & ST average maintained in the routing identifier record. According to the Edwards AFB study the average for the LP items should be at least 13 days more than is computed in current supply records. Thus, the customer will be misled to believe his item will be delivered almost two weeks prior to actual delivery (3:8). Thus, the use of the current method to compute O & ST can have an impact on mission effectiveness.

The Edwards AFB study was a valuable study in terms of identifying the problem; however, there were two weaknesses that this thesis sought to overcome. First, the study consisted of a limited sample: only four months of data at a single base. This thesis sought to analyze at least six months of data at nine Air Force installations. Second, the Edwards study did not document conclusive findings regarding the factors that cause the variance in O & ST averages. Thus, additional study was necessary to determine a more accurate method of computing O & ST average for LP items.

Summary

This chapter addressed the background information necessary to develop a predictive model for O & ST. First, the current system was documented to explain how O & ST

relates to Air Force stock levels, and its importance to cost effective inventory stockage. Next, some factors were discussed in an effort to provide a rationale for the hypotheses of this thesis, specifically, that three factors significantly influence the computation of O & ST. Finally, a study that documents that a problem currently exists with the computation of O & ST averages in the Air Force was highlighted. However, this study did not consider a large enough sample nor provide conclusive findings regarding the factors influencing O & ST.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

The current Air Force procedure for computing O & ST for LP items involves averaging the O & ST at each AF base for all LP items. Thus, the current method provides one overall O & ST for all LP items and does not consider any other factors in the computation of O & ST. This thesis hypothesized that a more accurate method of computing O & ST can be developed by considering factors that influence O & ST. This thesis has attempted to empirically support the hypothesis that homogeneous grouping, the method of procurement, and the nature of the item itself significantly affect the O & ST for LP items. Thus, it must be shown that the average O & ST considering these factors is statistically significantly different than the cumulative O & ST used by the current system. The methodology to support this prediction is outlined in this chapter. Specifically, this chapter provides a list of the variables that were empirically tested, the data gathering plan, the analysis procedures, the evaluation methodology including the criteria tests, and the method to develop an alternative computational method. The final section of this chapter discusses

the methodology for analyzing a procedural assumption used by the current system, specifically the effect of the 175 percent truncation on the computation of O & ST for LP items.

Variable Identification

Four variables were identified for analysis. The dependent variable was on the ratio scale, while the independent variables were on the nominal scale. The dependent variable, O & ST, was defined as the number of days between initiation of a stock replenishment requisition to receipt of the items by base supply (18:11-8). The three independent variables, whose effect on O & ST is being tested, were homogeneous grouping, method of procurement, and the individual item. The first independent variable, homogeneous grouping, has two distinct factors or levels. The two levels are national supply group and national supply class. National supply group refers to a general grouping of like items and is identified by the first two digits in a national stock number. National supply class is a more specific grouping of similar items and is identified by the first four digits of the national stock number. For example, national stock number 5120 00 210 1377 refers to national supply grouping 51 (tools) and national supply stock class 5120 (hand tools).

The next variable was the method of procurement, which consists of five mutually exclusive and collectively exhaustive categories. Table 5 provides a list and definition for these five categories. The definitions to complete this table were extracted from Air Force Manual 70-332 (16:74).

The final independent variable was the characteristics of the individual item. To determine if there is a difference in the O & ST between two different items, individual national stock numbers were used as the nominal variable levels. Thus, all requisitions with the same national stock number were grouped to measure the effect the individual item has on O & ST.

Data Gathering Plan

After the variables were identified and defined, sufficient data were gathered to provide a large enough sample to analyze the effects of these independent variables on O & ST for LP items. There were two parts to the data gathering plan: the selection of the sample and the procedures for gathering the data.

Population and Sample Selection

The computation of O & ST for LP items is conducted by the Standard Base Supply System at each Air Force base. Since each Air Force base uses the same computational

Table 5

Method of Procurement Operational Definitions

Procurement Method	Appropriate Computer Code*	Definition
Purchase Order	N	A purchase order is an offer by the government to buy the item as identified on the purchase order form. The purchase order is not a binding contract until the contractor begins performance.
Delivery Order	L,R	A delivery order is an order placed by the Base Procurement Office against an existing contract. The procurement computer code "L" refers to delivery orders for items that are normally not stocked, for example fuel or mixed cement.
Blanket Purchase Agreement	D	A blanket purchase agreement is synonymous to establishing a charge account via a contract. The designated Base Procurement Office personnel can order (via telephone) the items listed in the agreement.

*The computer code listed in the table refers to a code in card column 28 of the Base Procurement local purchase status data files in the B3500 base-level computer (16:74).

Table 5 (continued)

Procurement Method	Appropriate Computer Code	Definition
Contract	A	A contract is an agreement reached by two parties. This method of procurement involves formal advertising and negotiation.
Automatic Purchase Order	J	An automatic purchase order is a purchase order output by the B3500 base-level computer system. This method of procurement is used for low-value, high-turnover type items.

procedures for determining O & ST for LP items, the important consideration in selecting both the total number and the individual Air Force bases was to select a suitably representative sample to allow the conclusions of this thesis to be generalized to all Air Force bases. Initially, six Air Force bases were selected to provide the data. The selection of these six Air Force bases was a matter of convenience. Edwards AFB (Air Force Systems Command) was chosen because of that base's interest in the topic and the fact that data were already collected for analysis of O & ST (3:1). Eilson AFB and Elmendorf AFB (Alaskan Air Command) were selected because personnel from the Alaskan Air Command feel a problem exists with O & ST for LP items and requested to be part of the study. Tyndall AFB (Air Defense Command) and Maxwell AFB (Air University) were selected because of their proximity to the Air Force Data Systems Design Center, which was the organization sponsoring this thesis. Wright-Patterson AFB (Air Force Logistics Command) was added because of its proximity to the Air Force Institute of Technology. Since these initial six bases did not provide a truly representative sample, it was determined three more bases would be added. The three bases were selected by the major command involved. The three bases added were Offutt AFB, Ellsworth AFB, and Loring AFB of the Strategic Air Command. These bases were added to broaden

the data base and to verify the validity of an assumption discussed below which was necessary to the conduct of this study.

An inherent assumption existing in current policy was necessary for this study. The assumption was that the mission of the individual Air Force base and its geographical location are already considered in computing O & ST and do not affect the factors of O & ST considered by this study. The logic behind this assumption is based on policy made during the design of the SBSS and is provided here. The computational methodology for O & ST is the same at each Air Force base, thus even though the average O & ST varies from base to base, the computational procedures are standardized. Therefore, each Air Force base has a different average O & ST using the same computational procedures. The reason for the differences is based on the mission and geographical location of each Air Force base (13). Since these factors are already considered by having each individual Air Force base compute its own O & ST for LP items, it was assumed that they did not need further study here and that these factors would not affect the independent variables considered in this study. Thus, regardless if an item is ordered for a flying squadron in Florida or a communication squadron in Alaska, the computational methodology used to predict an accurate O & ST would be the same,

although the actual average O & ST for each base would be different.

Thus, data were collected from nine bases, which comprise six different major air commands, a variety of mission activities, and different geographical regions. The selection of nine bases provided as much data as could be analyzed in the time available, and more importantly, provided an appropriate sample which allowed inferences to be drawn to the remaining Air Force bases. More specifically, the relatively large number of bases selected (nine), the stringent criteria test--which stated that the significant factors must influence O & ST at all nine bases at a high confidence level (95 percent)--, the high geographical dispersion, and the wide variance in the missions attest to the representativeness of the analysis conducted in this thesis. If a more accurate method to compute O & ST for LP items could be developed and supported for these nine bases, then that same O & ST method could be inferred to hold at all Air Force bases.

Data Gathering Procedures

Once the sample Air Force bases were selected, the procedures for gathering the data were developed. The data were collected over an eight and one-half month period (1 November 1977--15 June 1978) from two different sources; therefore, there were two sets of procedures. The first

source was the standard Base Supply System (SBSS), where the O & ST, national stock number, requisition number, and other miscellaneous data were collected on computer cards. Thus, this source provided the data necessary to supply information on the dependent variable, O & ST, and two independent variables, the homogeneous grouping (national supply group and class) and the individual item (national stock number). Upon completion of the data gathering period, the AFDSDC issued instructions and provided a program to each base to use these computer cards to obtain the remainder of the data. The data to support the final independent variable, method of procurement, was gathered from the base-level Procurement System files in the Burroughs 3500 computer. The AFDSDC prepared a computer program which extracted the procurement data, matched it to the SBSS data, and printed both sets of data on a computer tape. The computer tape was forwarded to the AFDSDC by each base, and the AFDSDC, in turn, forwarded it to the authors of this thesis. Thus, the input data to this study consisted of a tape containing all the pertinent supply and procurement information regarding an individual LP requisition. This study used the total population of the data from each individual base to analyze that specific base. In other words, every requisition from a particular base was used in the analysis of the factors influencing O & ST for LP items at that particular base. Since each Air Force base averages

3,000-6,000 LP requisitions in a six-month period (3:Atch 1), there was sufficient data to conduct a statistical analysis.

Data Analysis Plan

Once the data were collected, they were analyzed using the statistical technique called analysis of variance (ANOVA). Analysis of variance was used instead of regression analysis because the independent variables were all nominal. Analysis of variance is a statistical method which compares two or more sample means to infer whether these means are the same as the population mean (19:213). Thus, this technique determined if the individual base's average O & ST considering the three independent variables, both individually and combined, yielded a different average O & ST than the base's overall average O & ST (which corresponds to the current method of computing O & ST). The analysis was run individually for each of the nine sample bases.

An ANOVA computer program is contained in the Statistical Package for the Social Sciences (SPSS), which is a collection of statistical analysis techniques, and was available on the computer system at Wright-Patterson AFB (8:403).

Two separate ANOVA programs were required; a two-way and a one-way. A two-way ANOVA was used when two dependent variables were analyzed. Specifically, the

two-way ANOVA was used to analyze the effect of the homogeneous grouping and type procurement variables on O & ST. The one-way was used to analyze the single dependent variable's (individual item) effect on O & ST. Since the individual item (the national stock number) already includes the stock group and stock class (homogeneous grouping), and since each individual item normally involves only one method of procurement, the one-way ANOVA was appropriate. Thus, these two ANOVA programs were used to analyze the O & ST data received from each base. The data from each base were analyzed separately from that of the other eight bases.

Evaluation Methodology

Once the data were analyzed using ANOVA techniques, the results were evaluated to determine if the independent variables--homogeneous grouping, method of procurement, or the individual item--affected the computation of O & ST for LP items. A statistical test was then performed which determined if the sample averages, considering the factors, were different than the population cumulative average. The statistical test used information obtained from the ANOVA program and the formula given below (19:215):

$$F_o = \frac{n s_{\bar{x}}^2}{s_p^2} \qquad F_c = F_{\alpha}\ ;\ r-1, r(n-1)$$

$$\text{Test } F_o > F_c$$

Where:

F_o = the test statistic

r = the number of factors being tested

n = the number of observations

$s_{\bar{x}}^2$ = the variance of the sample means

s_p^2 = the pooled variance of the sample means

F_c = the critical value of the F distribution at the α significance level with $r-1$ and $r(n-1)$ degrees of freedom

If the test statistic value (F_o) was greater than the critical value (F_c), then it was inferred that the factors did affect the computation of O & ST at the specified level of significance ($1-\alpha$).

For the purpose of this thesis the significance level was 95 percent. In an interview with personnel at the AFDSDC, it was determined the 95 percent significance level has been used in the past for statistical analysis on O & ST (13). Thus, to be consistent with past efforts and to insure a high degree of confidence in the findings, the results of this study had to be significant at the 95 percent level.

Additionally, the test must prove that these independent variables influenced O & ST at all nine sample Air Force bases. Since this thesis hypothesized that a better method to compute O & ST could be developed for total Air

Force use, the test had to hold for all the samples. Thus, only if it was supported that these variables significantly influence O & ST for LP items at these nine sample bases could the results be inferred to hold at all Air Force bases.

Alternative Computational Methods

A final step to consider in the methodology was the development and testing of alternative methods for computing O & ST for LP items. Since the computed O & ST is used as a forecaster of future requisition's O & ST, various forecasting techniques were selected as alternative methods. These techniques were regression, weighted average, and exponential smoothing. Each of these techniques were also compared to the current SBSS method of predicting O & ST using the mean squared error technique.

The first alternative technique to be tested was a mathematical equation based on regression. A regression model was developed by taking the factors that influence O & ST, as determined by the ANOVA technique, and using them as the independent variables in a multiple linear regression. The independent variables were "regressed" against the dependent variable, O & ST, with the output being an equation with regression coefficients, which in the case of nominal data actually represented a weighting factor according to its influence on O & ST for LP items. This was done

individually for each sample base. Consider the general sample multiple linear regression equation below (5):

$$y = b_o + b_i x_i + \ldots + b_n x_n$$

Where:

y	= Predicted O & ST
b_o	= Intercept coefficient or predicted value of O & ST and with the independent variables equal to 0
$b_{1 \ldots n}$	= Regression coefficients or the weight given the corresponding independent variable in predicting O & ST
$x_{1 \ldots n}$	= Independent variables

The second technique tested was based on weighted averages. Two separate models were tested using the weighted average technique. The first model was an adaptation of the model suggested by Captain Menestrina after the Edwards AFB study (3:11). The model tested was:

$$\left[\text{National Supply Group O \& ST Average} + 2\,(\text{National Supply Class O \& ST Average}) + 4\,(\text{National Stock Number O \& ST Average})\right] \times \frac{1}{7} = \text{Forecasted National Stock Number O \& ST}$$

This model was tested in two ways. First, overall averages by National Stock Group (NSG), Stock Class (NSC), and Stock Number (NSN) were used. The second way, the averages were segregated by type procurement code.

The second model using the weighted average technique was developed and proposed by Captain Menestrina (3:11). The model tested was:

$$\left[(\text{NSG Average} + 1 \text{ Standard Deviation}) + 2\,(\text{NSC Average} + 1 \text{ Standard Deviation}) + 4\,(\text{NSN Average}) + 8\,(\text{Most Recent NSN O \& ST})\right] \times \frac{1}{15} = \text{Forecasted O \& ST}$$

This model was also tested using both the overall averages and the averages for the type procurement.

The third technique tested was exponential smoothing model. Exponential smoothing models possess certain advantages; for example, these models are relatively easy to take new data points into consideration and require a *minimum* amount of data storage when compared to the other forecasting techniques (15:91). The general exponential smoothing model is provided below (15:91):

$$Y_t = \alpha X_t + (1-\alpha)\, Y_{t-1}$$

or

$$\text{Forecasted Estimate} = \alpha \begin{pmatrix}\text{New}\\ \text{Data}\end{pmatrix} + (1-\alpha)\begin{pmatrix}\text{Previous}\\ \text{Estimate}\end{pmatrix}$$

The term, α, is a smoothing constant, which is a number between zero and one. Various values of the smoothing constant were tested, as well as varying the value of the smoothing constant depending on the difference between the new actual O & ST and the previous estimate. Thus, a

number of alternative models--exponential, regression, and weighted averages--were developed.

The resulting mathematical models were tested individually on the data from each sample base. The result using each equation was compared to the actual O & ST average for a certain number of selected requisitions. A sample of requisitions of 10 individual stock numbers O & ST was computed using the current method and the alternative methods (based on the results of the thesis). The actual observed O & ST for each individual item in the sample was then compared to the other methods of computing O & ST. The comparison technique used was the mean squared error (MSE). The formulas used are provided below.

$$\left(\frac{(O\ \&\ ST)_{cm} - (O\ \&\ ST)_{o}}{n}\right)^2 = D_{cm}$$

$$\left(\frac{(O\ \&\ ST)_{am} - (O\ \&\ ST)_{o}}{n}\right)^2 = D_{am}$$

Where:

$(O\ \&\ ST)_{cm}$ = Forecasted O & ST using the current method

$(O\ \&\ ST)_{am}$ = Forecasted O & ST using the alternative methods

$(O\ \&\ ST)_{o}$ = Observed O & ST from the data collected

n = Sample size

D_{am} = Mean Square Error differences in O & ST using the alternative method

The method with the lowest mean squared error, the smallest value of D, was considered the more accurate. Again, the alternative method had to be more accurate at all nine Air Force bases to be considered usable Air Force-wide. In addition, the margin of difference had to be significant enough to more than offset the costs of converting to a new system and collecting the data necessary to support a new system.

Truncation Analysis

Prior to finalizing a study on the computation of O & ST for LP items, an analysis was conducted on the effect of the 175 percent truncation policy used by the current system. The current policy states that all values of O & ST above 175 percent of the UMMIPS standard are not included in the computation of the average O & ST. This policy was based on the assumption developed in a 1969 AFDSDC study that stated 80 percent of all requisitions' O & ST fall within 175 percent of the UMMIPS standard. This assumption was tested by computing the percentage of actual observation O & ST values less than or equal to 175 percent of the UMMIPS standard. The formula below illustrates the test:

$$\frac{(O \,\&\, ST)_O < \text{UMMIPS}^*}{(O \,\&\, ST)_T} \geq 80\%$$

Where:

$(O \,\&\, ST)_O$ = Number of observed O & ST values less than the UMMIPS standard

$(O \,\&\, ST)_T$ = Total number of O & ST values observed

UMMIPS = Standard as described in AFM 67-1

If this percentage was significantly below 80 percent at all nine bases, a recommendation was made to either increase the UMMIPS standard or raise the truncation percentage. The increase in the standard or truncation would insure 80 percent of the values were considered in computing O & ST for LP items. Thus, this final test on the truncation was run prior to completing a final report on the computation of O & ST for LP items.

Summary

This chapter has provided the methodology that was used to analyze factors that significantly influence O & ST for LP items and develop an alternative method for computing O & ST for LP items. The chapter listed and defined the

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*There are three UMMIPS standards based on the requisition priority. The 175 percent for all UMMIPS standards are: 21 days for priority 01-03, 32 days for priorities 04-08, and 79 days for priorities 09-15 (18:11).

variables studied and how the data to support these variables were gathered. A list of the sample bases and an explanation of how these bases were selected was also provided. The chapter continued with a description of the statistical analysis techniques, ANOVA, and how this technique was used to determine if various factors have an effect on O & ST for LP items. The evaluation methodology was also described. The chapter concluded with a discussion of the analysis and evaluation of a related issue involving O & ST for LP items, that was the effect of the truncation of all values of O & ST over 175 percent of the UMMIPS standard.

CHAPTER IV

DATA PRESENTATION

Introduction

The data were collected as indicated in the "Data Gathering Plan" in Chapter III. The nine sample Air Force bases collected the Pipeline Time Cards (PTC) containing the O & ST values that were output from the Standard Base Supply System, and then used an Air Force Data Systems Design Center (AFDSDC) program to collect the type procurement code from the Base Procurement computer files. The resultant data were placed on tape and forwarded through the AFDSDC to the authors. This chapter provides a description of the data collected and the actions required to manipulate the data into usable information for analysis and recommendations.

Data Description

The data provided for this study consisted of data readily available at each base with a Standard Base Supply System (SBSS). All but one data element is contained on the Pipeline Time Card, which is a card output by the SBSS. The one data element missing was the type procurement code which was contained in Base Procurement automated data files on

the Burroughs B3500 computer. Figure 2 is a page of data provided from Loring AFB, and includes a description of the data by column. To reemphasize, no additional data, other than the data currently collected at each Air Force base, was required to conduct this analysis and derive a more accurate measure of O & ST. Thus the data to support any recommendations developed by this study can be readily obtained at base-level.

There was a considerable amount of data available that was collected from each of the nine bases. Table 6 provides a list of the bases, the inclusive dates for the collection of each base's data, the number of records per base, and the stock record account numbers (SRAN) of the data collected. The SRAN is a number that identifies the particular transaction to the base or a satellite activity of that base. Since this thesis was primarily interested in the nine bases' O & ST (and not the satellites), some of the data collected were not used in the analysis. Thus, the data required manipulating prior to the analysis phase.

Data Manipulation

A series of edits were conducted on the data. These edits varied depending on the analysis conducted. This section provides the edits conducted for each analysis, and thus is organized by type of analysis. There were three separate groups of analyses conducted. The first was the

```
CARD COL 1      10        20          30          40          50       60         70          80
*PTCJBB 6830002617485  GL00470FB4678005997240861 40 046 01    12 XB3810400336     2
*PTCJBB 6830002646751  CF00450FB4678003997230855 20R038 01    12 XB3807605203     2
*PTCJBB 6830002646751  CF02250FB4678801797270855 20R098 01    16 XB3811603343 B5  1
*PTCJBB 6830002646751  CF00675FB4678804797210855 20R030 01    12 XB3807605195     2
*PTCJBN 6830002646751  CF00225FB6181803103470855 20 038 A1    12 XB3806802302     2
*PTCJBN 6830002646751  CF00225FB6181804702390855 20 023 A1    12 XB3806904283     2
*PTCJBN 6830002646751  CF00225FB6181812501520855 20 032 A1    12 XB3815603389     2
*PTCJBB 6830002865434  CF00040FB6181804406830855 20 005 A1    12 XB3808834440     2
*PTCJBB 6830002904291  CF00220FB6181734004350855 00 093 A1    12 XB3806702108     1
*PTCJBB 6830002904291  CF00220FB6181804501170855 00 023 A1    12 XB3806702100     2
*PTCJBB 6830002904291  CF00220FB6181807404000855 00 024 A1    12 XB3809704486     2
*PTCJBB 6830002904291  CF00220FB6181804710650855 00 024 A1    12 XB3811001984     2
*PTCJBB 6830002904291  CF00220FB6181803301580855 00 018 A1    12 XB3811001990     2
*PTCJBB 6830002904370  CF00120FB4678060972308552 0R055 01    12 XB3811403365     2
*PTCJBB 6830002920129  CF00440FB4678904797200861 20R030 01    12 XB3807505191     2
*PTCJBN 6830002920129  CF00440FB6181814405680861 20 013 A1    12 XB3815603379     2
*PTCJBN 6830002920129  CF00220FB6161804100960861 20 027 A1    12 XB3806702091     2
*PTCJBN 6830002920129  CF00440FB6181813700580861 20 009 A1    12 XB3814502469     2
*PTCJBN 6830002920129  CF00440FB6181803301920861 20 018 A1    12 XB3811001978     2
*PTCJBB 6830002920129  CF00880FB4678801797260861 20R098 01    12 XB3811404739 B5  1
```

Figure 2. O & ST Data Description

Card Col	Nr Pos	Description	Remarks
1-3	3	Transaction Identification Code	PTC
4-6	3	Routing Identifier	
7	1	Blank	
8-22	15	Stock Number	
23-24	2	Unit of Issue	
25-29	5	Quantity	
30-43	14	Document Number	
44-49	6	National Motor Freight Code	
50	1	Type Procurement Code	
51-53	3	Order and Ship Days	
54	1	Blank	
55-56	2	System Designator	
57-59	3	Project Code	
60-61	2	Priority Designator	
62	1	Blank	
63-65	3	ERRCD	
66-74	9	Transaction Serial Number	
75	1	Airlift Investment Code	
76-77	2	Status Code/Mode of Shipment	
78-79	2	Previous Status	
80	1	Indicator	Note 1

Note 1: Indicator 1--O&S time was not updated (days exceeded 175% of standard).

Indicator 2--O&S time was updated.

Figure 2. O & ST Data Description (Continued)

Table 6

Data Volume by Base

Base	Number of Records	Inclusive Date	SRAN
Loring	1909	8046-8160 15 Feb 78- 9 Jun 78	3
Edwards	9092	7305-8159 1 Nov 77- 8 Jun 78	1
Wright-Patt	9286	7321-8160 17 Nov 77- 9 Jun 78	1
Maxwell	8064	7314-8159 10 Nov 77- 8 Jun 78	2[1]
Ellsworth	2242/66[2]	8046-8160 15 Feb 78- 9 Jun 78	3
Eielson	1786	7299-8159 26 Oct 77- 8 Jun 78	1
Tyndall[3]	383	8150-8165 31 May 78-14 Jun 78	1
Offutt[3]	1265	8122-8160 3 May 78- 9 Jun 78	1
Elmendorf	1411	7299-8159 26 Oct 77- 8 Jun 78	1

Notes:

1. The major command designation for Maxwell AFB was transferred from Air University to Air Training Command during the period of data collection. The transfer to another MAJCOM required a new SRAN designation, thus all the data collected were from Maxwell AFB even though two SRANs were involved.
2. The original tape containing data received from Ellsworth AFB did not have the type procurement code, thus requiring a resubmission by personnel at Ellsworth AFB. However, the resubmitted tape only included 66 records. Therefore, Ellsworth data were not included in any of the analysis requiring the type procurement code.
3. Both Tyndall and Offutt AFBs began collecting data late, due to selecting the incorrect option for LP O&ST. However, data from these bases were used whenever a sufficient size sample could be selected.

analysis of variance which consisted of two parts: two-way analysis of variance by type procurement and homogeneous grouping, and a one-way analysis of variance by individual item. The second group of analysis was the mean square error analysis of alternative computational methods. The final group of analysis was the 175 percent truncation analysis.

The purpose of the first of the two analyses of variance (ANOVA), the two-way analysis, was to determine the effect of the type of procurement and the homogeneous grouping on the O & ST. Initially, four stock groups having the largest number of local purchase requisitions were selected to measure the effect of the first level of homogeneous grouping, the National Stock Group (NSG). A two-way ANOVA was run on the four selected NSGs and type procurement. A list of four NSGs selected for each base is provided in Table 7, which is found near the end of this chapter.

Following the two-way ANOVA on the NSG, a two-way ANOVA was performed on National Stock Classes (NSC). Since an analysis had already been conducted on NSG and was found significant, the NSC analysis had to insure the NSG effect was not included in the NSC analysis. Thus, the National Stock Classes to be analyzed were selected from a single NSG that was included in the previous analysis for that base. The number of stock classes selected and which NSG to select

depended on obtaining a sufficient sample size. The criteria for sample size (and thus the choice of NSC) was to select an NSC with 25 or more requisitions. A two-way ANOVA was then run on the NSC and type procurement. Table 7 provides a list of stock groups and stock classes selected for each base. For both the NSG and NSC ANOVA a sort was made on routing identifier code JBB, priorities 11-15, and expendability-repairability-recoverability-code (ERRC) XB3. Thus, only Base Procurement procured (JBB), stock replenishment requisitions (priorities 11-15) for stock items (XB3) were used in the two-way ANOVAs.

The second analysis of variance group, the one-way analysis, included the same edits as the two-way analysis with two differences. The one-way analysis was conducted on stock numbers, which were selected from a list of stock numbers with four or more requisitions. Again, since the previous analysis had concluded that the NSG and NSC significantly affect O & ST, the stock numbers selected had to assure these factors did not affect the one-way analysis by individual item. Thus, the stock numbers to be analyzed were selected from within the same NSC (and subsequently the same NSG). Table 7 contains the stock numbers selected for each base. The second difference was an additional sort on the SRAN. This sort was required to insure only O & ST from the requisitions from the individual base and not any of its satellites were selected for analysis.

The third group of analysis was the comparison of the alternative O & ST computational methods. This analysis involved determining the mean square error of the difference between the actual O & ST for a sample of requisitions and the predicted O & ST determined using various alternative methods. The sample of requisitions to use in the comparison analysis was drawn from a list of stock numbers with four or more requisitions contained in the data. Stock numbers were selected rather than just a selected number of O & ST occurrences for two reasons. The first was to ease the task of conducting the analysis. To select O & ST occurrences from more than ten NSGs would have required significantly more programming manhours. Secondly, and more importantly, the forecasting techniques analyzed required numerous requisitions on the same stock number to determine their effectiveness. Thus, stock numbers with four or more requisitions were necessary. This analysis was conducted to determine the effectiveness of the alternative forecasting techniques for use Air Force-wide. Therefore, the selection of a sufficiently representative sample was necessary. Since a broad sample was required, ten stock numbers were drawn, each from a different NSG and NSC. Since each stock number contained at least four requisitions, but usually more than four, the sample size exceeded 50 for each base. The sample of requisitions included only priorities 11-15,

base procured, stocked items. Table 7 contains a list of the stock numbers selected for each base.

The 175 percent truncation analysis was the final analysis conducted. The edits used for the previous three analyses were used for the 175 percent truncation analysis. Specifically, only requisitions with JBB routing identifier code XB3 ERRC, and the individual base's SRAN were selected. Once the requisitions with these three sorts were segregated, the requisitions were grouped according to priorities as indicated below:

Requisition Priority	Priority Group	175% of Standard Days
01-03	1	21
04-08	2	32
09-15	3	79

The 175 percent truncation analysis compared the actual O & ST to the 175 percent of the UMMIPS standard for each priority group to determine the number of local purchase requisitions exceeding standards.

Table 7

Sample Selection by Base

Type Analysis	Homogeneous Grouping		Individual Item	Alternative Computational Methods
Base	National Stock Group	National Stock Class	National Stock Number	National Stock Number
Loring	62	7510	NA	1680007061484
	72	7520		5510005506968
	75	7530		5805005033335
	78			5961PA645-1404
				6240001325328
				6350P220-011
				6650005301880
				6750PTYPE360
				6830006169183
				7530L0000714678
Wright-Patterson	53	5305	5340P0484802300	3020L0451582300
	59	5306	5340P0573162300	4820P0051162300
	67	5310	5340PP1A1A1	4710002028220
	75	5315	5340PPZB7004M1	3439L01009302300
		5330		4130P0P310
		5340		4510P1141
				4730P0677192300
				5120002933344
				5510L0045632300
				6145P5314002

Table 7 (continued)

Type Analysis	Homogeneous Grouping		Individual Item	Alternative Computational Methods
Base	National Stock Group	National Stock Class	National Stock Number	National Stock Number
Maxwell	62	7510	7510L0030023300	3020004294436
	72	7520	7510L0030123300	4130PFE-14
	75	7530	7510PN05067011	4510P400
	78		7510PZ2-1	4710005110858
			7510004665374	4820PB135
				5510L0039893300
				3439L0003153300
				4730L0011963300
				6140PPE7-6
				5120004910800
Edwards	45	4510	4510P0081912805	3020P00442420805
	51	4520	4510P30-010	4130PFP573308
	53	4540	4510P2416	4510L0057062805
	59		4510P893	4710L0080102805
			4510P871R	4820PF-8
			4510P7300	5510PL72A500M
			4510PJR3221	3439P5ILF051-32
			4510PMDL3-143	4730004063326
				6145P75050
				5120001856761

Table 7 (continued)

Type Analysis	Homogeneous Grouping		Individual Item	Alternative Computational Methods
Base	National Stock Group	National Stock Class	National Stock Number	National Stock Number
Offutt	62	NA	NA	2610P10=225MS
	59			6730PMODEL010
	75			7045001303273
	67			7430010274432
				7530007826225
				7910L0074764600
				8030PPWC-9
				8415008585603
				9310P1073
				6240002952652
Eielson	62	7510	NA	2530007591097
	72	7520		2610P171673311
	75	7530		3830004370522
	78			4210PNE-33
				3120P189120
				3130L0009785004
				3830004370522
				4320L0010265004
				4520L0017435004
				5670003368998
				8020L0039615004

Table 7 (continued)

Type Analysis	Homogeneous Grouping		Individual Item	Alternative Computational Methods
Base	National Stock Group	National Stock Class	National Stock Number	National Stock Number
Tyndall	53	NA	NA	3455P429D36
	59			4130PAME2057
	67			5130P06141
	75			5350001876278
				5610002677136
				5962P1458CP1
				6750PTYPE370
				8040P1473
				8430001445220
Ellsworth	NA	NA	NA	2910001108406
				4140PSDE20-32-B
				5330L0013534690
				5510L0021704690
				6210PUG1
				6830001690794
				9150001866703
				7510L0016454690
				5640002350255

Table 7 (continued)

Type Analysis	Homogeneous Grouping		Individual Item	Alternative Computational Methods
Base	National Stock Group	National Stock Class	National Stock Number	National Stock Number
Elmendorf	53	5975	5930P0058025000	3030P0603655
	59	5930	5930F016-85000	4130P623772
	67	5925	5930P1451I	4510P6273
	75	5950	5930P1PL4	4710P93189
			5930P5946	4820PEZT134
			5930P16879	5510L0033825000
				3439PSTAYBRITE
				5305PFIG146
				6150010099175
				7530004501474

At this point, a few observations must be made regarding the information contained on Table 7. The main criteria for selection of the data for each analysis was to generate sufficient sample size to provide the maximum statistical leverage. As explained in this chapter, the analyses were stair-stepped; the next lower level analysis selected data used in the previous analysis. Thus, the selection of the higher level analysis was to a certain extent contingent upon providing sufficient data for the next lower level analysis. The need for the largest sample size and the stair-stepping analysis approach then explains the reason that consistent NSG, NSC, and NSN could not be used at each base for each analysis. The sample available with the most observations was selected at each base. The sample size criterion was also the reason some analyses were not conducted at all the bases. The NSG, NSC, and NSN analyses were not run on Ellsworth AFB data because of an error in the tape as described in Table 6. However, sufficient sample size (at least three NSC with 25 or more observations) could not be generated for Tyndall AFB and Offutt AFB for the NSC analysis. In addition to these two bases, sufficient sample size (at least three NSN with four or more observations and at least one of the three NSNs having eight or more observations) for Loring AFB and Eielson AFB could not be generated for the NSN analysis. Thus, there were some data limitations to the analysis of factors affecting O & ST.

The data limitations, however, do not reduce the significance of the analyses or the findings of this thesis. This conclusion is reached for two reasons. First, the data limitations affect only the analysis that identifies the factors having a significant effect on O & ST. With the exception of portions of the alternative computational methods analysis for Ellsworth AFB, the other two analyses, the analysis of the alternative computational methods and the analysis of the effect of the 175 percent truncation, were conducted for each base. The second reason is that the analysis of the factors affecting O & ST was still at six bases for the NSC analysis and four bases for the individual item analysis. Further the analysis of alternative computational methods actually tests the findings of the analysis of significant factors, and thus provided any verification necessary as to the significance of the factors on O & ST. Thus, although some limitations in the data existed, sufficient analyses were still conducted to provide meaningful results for consideration for Air Force-wide use.

Summary

This chapter provided a description of the data collected. The data provided and the data's format were the same as the SBSS produced Pipeline Time Card with the addition of a one digit type procurement code from the Base Procurement Office's files. Thus, the data were readily

available at each base. This chapter also described the manipulation of the data that was required and the specific data selected for each of the three groups of analysis: the analysis of variance, the mean square error analysis of alternative computational methods, and the 175 percent truncation analysis.

CHAPTER V

ANALYSIS AND FINDINGS

Introduction

As indicated in Chapter III, there were three distinct groups of analysis. The purpose of the first group of analysis was to determine if there are significant factors that affect O & ST and involved the use of Analysis of Variance (ANOVA) techniques. The goal of the second group of analysis was to evaluate alternative methods for computing O & ST, with the alternative methods including the significant factors found in the initial ANOVA process. The final group's aim was to analyze the effects of the current policy to truncate all values of O & ST that exceed 175 percent of the UMMIPS standard. This chapter provides the results of these three groups of analysis.

Analysis of Variance

Two distinct ANOVA processes were used: the two-way ANOVA and the one-way ANOVA. Each process is discussed separately.

Two-Way ANOVA

The purpose of the two-way ANOVA was to determine the effect of the dependent variables, homogeneous grouping

and type procurement, on the O & ST. Since there were two levels of homogeneous grouping, National Stock Group (NSG) and National Stock Class (NSC), a separate two-way ANOVA was run for each level at each base. The first two-way ANOVA run was for the National Stock Group and the results are provided in Table 8. Table 8 provides the significance level for the effect that the National Stock Group (NSG), the type procurement, and the main effect, which is the effect of the NSG and the type procurement combined. The significance level shown in the interaction column indicates the degree of dependence between the two main effects. In other words, the interaction column answers the question: to what degree does a particular commodity group determine the method of procurement? As defined in the evaluation methodology in Chapter III, a significance level of .950 (95 percent) indicated the factors evaluated had a significant effect on O & ST. The last column on Table 8 provides the total sample size for the ANOVA. Table 9 provides further information on the sample size and O & ST average by NSG and by type procurement. Every attempt was made to insure sufficient sample size was generated; and for the ANOVA by NSG and type procurement, only Tyndall AFB lacked sufficient sample size.

The results of the two-way ANOVA by NSG and type procurement were considered conclusive. Statistically, at each base at least one sample mean for a particular type

Table 8

Two-Way ANOVA O & ST by NSG and Type Procurement, Significance Level

Bases	NSG	Type Procurement	Main Effects	Interaction	Sample Size
Loring	.999	.001	.999	.999	445
Eielson	.999	.999	.999	.914	946
Maxwell	.999	.999	.999	.999	1474
Wright-Patterson	.999	.999	.999	.999	3066
Tyndall	.811	.985	.998	.001	68
Offutt	.987	.999	.999	.710	536
Edwards	.999	.999	.999	.001	1848
Elmendorf	.999	.999	.999	.999	1606

Table 9

Two-Way ANOVA O & ST by NSG and Type Procurement

	Loring		Eielson		Maxwell		Wright-Patterson		Tyndall		Offutt		Edwards		Elmendorf	
	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.
Type Proc																
1	251	45.8	834	82.5	497	89.3	810	88.7	48	61.0	336	70.3	1364	79.3	1174	94.3
2	193	45.1	64	91.3	551	71.9	871	76.6	16	33.2	164	52.6	16	68.7	358	81.9
3							1180	92.0							13	130.8
4	1	11.0	48	33.6	426	47.6	205	48.8	4	21.2	36	41.0	468	37.0	61	49.6
NSG[1]																
1	81	45.9	423	84.2	201	60.2	805	73.2	23	50.9	25	63.5	574	60.1	734	91.0
2	47	70.3	262	87.3	87	67.6	923	106.0	14	74.6	30	89.2	606	78.1	558	83.3
3	170	36.5	58	70.1	646	52.5	546	71.6	18	39.5	335	66.6	346	57.1	156	85.2
4	147	48.2	203	67.6	540	97.0	792	77.4	13	47.7	146	50.9	322	77.6	158	111.0

Note

1. The particular stock groups used for each individual base are indicated in Table 7.

LEGEND

Type Procurement 1 = Purchase Order (N)
2 = Delivery Order (R and L)
3 = Blanket Purchase Agreement (D)
4 = Automatic Purchase Order (J)

procurement code was significantly (at the 95 percent level) different from another type procurement sample mean. Similarly, at least one NSG sample mean was different (at the 95 percent significance level) from another NSG sample mean for that base. Only Tyndall AFB failed to meet the 95 percent significance level for NSG. Although the significance level for type procurement at Loring AFB did not meet the 95 percent, the type procurement factor was still considered significant because of the 99.9 percent significant level for both the main effects and interaction. If interaction was significant, it may be concluded that the effect of type procurement varies from one NSG to another. Since the main effects were significant and the effects of type procurement vary, there was no reason to test the significance of each main effect separately (8:403). Thus, the results were conclusive; both the NSG and method of procurement significantly affect O & ST.

The next step was to determine the effects of the National Stock Class (NSC) in combination with the type procurement on O & ST. Thus, a two-way ANOVA was run for each base to test the effects of NSC and type procurement. The results of this two-way ANOVA are provided in Tables 10 and 11. Although not as conclusive as NSG, the two-way ANOVA by NSC and type procurement provided supportive evidence that NSC does affect O & ST. Although only half of the bases tested met the 95 percent criteria test, the lowest

Table 10

Two-Way ANOVA O & ST by NSC and Type Procurement, Significance Level

Bases	NSC	Type Procurement	Main Effects	Interaction	Sample Size
Maxwell	.999	.999	.999	.999	736
Wright-Patterson	.932	.999	.999	.765	678
Loring	.837	.890	.879	.974	101
Eielson	.999	.999	.999	.999	202
Elmendorf	.733	.999	.999	.001	269
Edwards	.999	.999	.999	.751	336

Table 11

Two-Way ANOVA O & ST by NSC and Type Procurement

Base	Maxwell		Wright-Patterson		Loring		Eielson		Elmendorf		Edwards	
	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.	Sample Size	Ave.
Type Proc												
1	245	46.4	173	99.4	70	45.8	172	60.9	230	90.0	206	73.2
2	358	53.0	48	75.2	30	41.0	31	103.9	21	62.8		
3			363	69.2					5	165.0		
4	133	44.2	94	42.8	1	11.0			13	31.9	130	31.5
NSC[1]												
1	259	56.4	35	64.6	60	42.4	110	80.6	94	81.8	260	49.0
2	345	38.6	20	73.5	26	43.0	64	52.9	33	84.9	52	76.6
3	132	62.9	29	71.1	15	52.5	29	50.6	111	90.6	24	102.4
4			20	104.5					31	88.1		
5			185	79.5								
6			389	70.3								

[1]The particular stock classes used for each individual base are indicated in Table 7.

LEGEND

Type Procurement 1 = Purchase Order (N)
2 = Delivery Order (R and L)
3 = Blanket Purchase Agreement (D)
4 = Automatic Purchase Order (J)

significance was 73.3 percent. Thus, it was concluded that NSC does have some effect on O & ST and that the NSC factor would be considered in the development of alternative computational methods. The next factor considered was the characteristics of the individual item.

One-Way ANOVA

The one-way ANOVA sought to determine if the individual item significantly affected the O & ST or, to state it differently, to determine if the O & ST average for a particular stock number was significantly different than the O & ST for the other stock numbers. One problem inherent to this analysis was that the sample size, the number of requisitions for each stock number, was smaller than desirable for the ANOVA technique. Optimally, each cell (in this case, each stock number) should contain at least 25 observations. Although the total sample size exceeded 25 observations, the individual stock number had only 4-16 observations. Nonetheless, the analysis was conducted and the results are provided in Table 12.

Table 12

One-Way ANOVA O & ST by Individual Item

Base	Significance Level	Total Sample Size
Wright-Patterson	.998	35
Edwards	.988	63
Maxwell	.994	32
Elmendorf	.577	51

With the exception of Elmendorf AFB, the characteristics of the individual item were significant at the 95 percent level. It was conjectured that the items selected were technical in nature (Stock Class 59, Electronics), and therefore were procured from continental United States (CONUS) sources. The extra dependent variable of transportation could have affected the independent variable. Personnel from the Alaskan Air Command have indicated that transportation time does increase O & ST for the Alaskan bases (20).* Thus, due to the intervening dependent variable of transportation for Elmendorf, and the conclusive findings for the other three bases, it was determined that the effect of the individual item would be used in the development of alternative computational methods.

Analysis of the Alternative Computational Methods

The ANOVA techniques provide statistical data to support the hypothesis that the dependent variables--NSG, NSC, type procurement, and the individual item--affect the independent variable, O & ST. The knowledge gained from

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*One of the reasons for Alaskan Air Command participation in this study was that command's long time interest in O & ST for Local Purchase items. The fact that the majority of their LP items have to be procured from CONUS sources greatly increases their average O & ST. Coupled with the 175 percent truncation policy, this causes considerable support problems for the Alaskan bases (20). This contention was supported by the findings of this thesis.

these analyses were used to derive four alternative computational models, which were compared to each other. Originally, a multiple regression analysis was planned to develop one of the alternative computational models. However, the analysis using the ANOVA technique provided the correlation coefficient (r) considering the three dependent variables. The values of the correlation coefficient varied from .258 (Elmendorf AFB) to .580 (Eielson AFB), and these values were not considered significant enough to use the regression technique. The authors felt a correlation coefficient (r) of at least .75 was necessary to conduct a regression analysis. Another reason a regression analysis was not used was the impracticability of its use Air Force-wide. Not only would regression require a relatively large data collection effort and computing power, but it would also require the use of a different forecasting model at each Air Force base. This lack of standardization combined with the higher cost (for data collection and computer computation) would make the regression model impractical. This section then highlights the development of the four alternative models, and provides the results of the comparison analysis using actual sample data.

The four models used in the alternative computational methods analysis were: the current SBSS, weighted average, exponential smoothing, and the Edwards AFB model. Each model is explained below.

1. Current SBSS Model: The baseline model was the current SBSS model, which is an average of the actual O & ST values. Three variations of the model were used; one where the O & ST values over 175 percent of standard were not truncated, the second with truncation, and the third variation without truncation and with a sort on the type procurement. The first variation of the SBSS model was an average of all the actual O & ST occurrences. The general model was:

$$\text{Projected O \& ST} = \frac{\sum_{i=1}^{n} \text{O \& ST}_i}{N}$$

where N equaled the total sample size for that base. Thus, the total observations for that base were used to derive the projected O & ST, not just the sample of 10 stock numbers. As is the current practice, the projected O & ST was not changed for each observation. The second variation used was the same as the general model except that all O & ST occurrences over 175 percent of the UMMIPS standard (79 days for priority group 3) were not included in the model. The final variation again was the same as the general model above except four different projected O & ST were developed, one for each type of procurement.

2. Weighted Average Model: The weighted average model took advantage of the significant factors NSG, NSC, and the NSN (the individual item). The model used was:

$$\text{Projected O \& ST} = \left[(\text{NSG O \& ST Average}) + 2(\text{NSC O \& ST Average}) + 4(\text{Previous NSN O \& ST})\right] \times \frac{1}{7}$$

where the NSG and NSC averages were the actual O & ST averages for the particular stock group and stock class for that NSN. A second weighted average model was also tested; the weighted average model with type procurement. This second model was the same as the weighted average model; however, it takes into consideration one other factor, the type procurement code. Thus, the NSG, NSC, and NSN O & ST averages only included those observations with the same type procurement code as the item for which the O & ST was being projected. For example, if the item being ordered has a type procurement code J (automatic purchase order), the NSG O & ST average will include only past observations with type procurement code J in that particular NSG. A static model was used for both weighted average models tested, thus once the projected O & ST was determined, that value was used to compare to the actual observed value for each occurrence in the sample.

3. <u>Exponential Smoothing</u>: An exponential smoothing model was analyzed. The general model is shown below:

$$\text{Projected O \& ST} = \text{Previous Projected O \& ST} + \alpha\,(\text{Previous Projected O \& ST} - \text{Actual O \& ST})$$

where α, the smoothing parameter, is a number between 0 and 1. Additionally, a seed is as required. A seed is the initial value to be used for the previous projected O & ST value in the model above. An exponential smoothing model was developed for each type procurement, and the seed used was the overall average O & ST for stocked items (priority 11-15) for each type procurement code. Thus, the model was based on sufficient sample size (all priority 11-15 O & ST occurrences) to provide a reasonable, initial projected O & ST.

The model was changed by differing the values of the smoothing parameter. Additionally, an adaptive exponential smoothing model was analyzed. An adaptive model is a model where the value of the smoothing parameter changes as the magnitude of the difference between the forecast and actual O & ST changes. Various combinations of values for the smoothing parameter and the maximum difference between the forecast and actual O & ST were tried. A plot of the data revealed a constant, but highly variable trend. Therefore, values closer to the mean were assigned higher smoothing parameter values (.1, .07, and .03), and the more extreme values were assigned a lower weight (.01). Two distinct values were used for the maximum difference, the point at which the smoothing parameter value changes. The two values were: a difference greater than one standard deviation and a difference greater than one half of a

standard deviation. Table 13 shows the results of the comparison of the variations in the exponential smoothing model.

For the exponential smoothing model the forecasted O & ST was updated for each data occurrence and a separate forecast was derived for each type of procurement. The exponential model used in the comparison with the other computational methods was the exponential smoothing model having the lowest mean squared error, which was the exponential smoothing model with .01 as the value of the smoothing parameter (α).

4. <u>Edwards AFB Model</u>: Edwards AFB conducted a study on local purchase O & ST, and submitted a model to AFDSDC for evaluation. The model used was as shown below:

$$\text{Projected O \& ST} = \left[(\bar{X}_{NSG} + \sigma_{NSG}) + 2(\bar{X}_{NSC} + \sigma_{NSC}) + 4(\bar{X}_{NSN}) + 8(\text{O \& ST}\right] 1/15$$

where:

$(\bar{X}_{NSG} + \sigma_{NSG})$ = O & ST average for the NSG plus one standard deviation

$(\bar{X}_{NSC} + \sigma_{NSC})$ = O & ST average plus one standard deviation for the NSC

$(\bar{X}_{NSN})$ = O & ST average for the NSN

(O & ST) = O & ST for the latest observed NSN

Two variations of this model were tested. The first variation was as shown above. The second variation segregated the model for each type procurement. These two models were

Table 13

Comparison of the Variations in the Exponential Smoothing Model

Base	Smoothing Parameter Values	Mean Square Error			Adaptive (see note)	
		.01	.03	.1	.1/.07 and .01	.03 and .01
Wright-Patterson		2613.0	2817.1	14647.0	3257.0[1]	2665.8[4]
Maxwell		1040.1	1052.2	1141.6	1186.4[2]	1045.2[4]
Edwards		673.1	681.2	1084.0	743.0[3]	688.0[3]
Elmendorf		1790.5	2565.7	196876.4	2474.7[2]	1885.8[4]
Tyndall		1727.5	1735.9	1790.3	1727.5[1]	1727.5[4]
Loring		290.6	290.4	380.2	290.0[4]	290.4[4]
Offutt		309.8	316.6	339.6	311.3[1]	310.1[4]
Eielson		558.2	593.7	2110.6	1527.0[2]	590.7[3]

Notes

1. Smoothing parameter = .1, Adaptive limit = 1 standard deviation
2. Smoothing parameter = .1, Adaptive limit = 1/2 standard deviation
3. Smoothing parameter = .07/.03, Adaptive limit = 1 standard deviation
4. Smoothing parameter = .07/.03, Adaptive limit = 1/2 standard deviation

dynamic, that is the projected O & ST were updated after each observation.

Analysis Results

Prior to discussing the specific alternative computational methods, two general conclusions are appropriate. The first conclusion involves the high variability of the distribution of O & ST for LP items. For each base, O & ST occurrences involved a constant, highly variable trend. The high variability was especially apparent with certain methods of procurement. The O & ST for blanket purchase agreement (type procurement code D) requisitions were the most variable, followed by delivery order (type procurement L or R) and purchase order (type procurement N). The O & ST for automatic purchase order requisitions (type procurement code J) were the least variable, therefore consistently possessing the lowest mean square error. Thus, O & ST inherently is difficult to predict with a high degree of accuracy. A second conclusion, and a logical extension of the high variability conclusion, was the fact that static models proved more accurate than the dynamic models. The exponential smoothing models (especially the adaptive models and the models with the higher smoothing parameter values) and the Menestrina model were dynamic models and therefore were not as accurate as the weighted average and moving average models.

As indicated by the results shown in Table 14, each of the alternative computational methods were more accurate (smaller mean square error) than the current method (columns 2 and 3). As expected, whenever one or more of the significant effects, type procurement, homogeneous grouping, or the individual item, were added to the model, it improved. The method with the most consistent least mean square error was the weighted average model segregated by type procurement. However, the weighted average model requires a large amount of data collection compared to the exponential smoothing and moving average (SBSS) models. Therefore, a cost/benefit analysis should be conducted prior to selection of a model for Air Force-wide use. However, a significant improvement (15-67 percent lower mean square error) can be made by using a moving average for each of the four methods of procurement. This would incur little additional expense.

Another significant finding of the alternative computational methods analysis involved the current 175 percent truncation policy. The results were inconsistent regarding the effect of truncation on the mean square error. The results in columns 2 and 3 of Table 14 indicate the mean square error for the truncated average was significantly lower (at the 95 percent confidence level) for four bases (Maxwell, Elmendorf, Loring, Ellsworth); significantly higher for three bases (Edwards, Tyndall, Eielson); and no significant difference existed at two bases (Wright-Patterson,

Table 14

Mean Square Error Analysis

Base	SBSS Without Truncation With Type Proc	SBSS Without Truncation Without Type Proc	SBSS With Truncation	Weighted Average Without Type Proc	Weighted Average With Type Proc	Exponential	Menestrina Model Without Type Proc	Menestrina Model With Type Proc
Wright-Patterson	2586.0	3040.5	3044.3	1684.5	1611.2	2613.0	2155.0	2046.0
Maxwell	1069.0	1507.0	827.6	533.6	484.7	1040.1	398.9	417.1
Edwards	672.8	1333.3	1600.1	698.4	552.0	673.1	1007.3	732.5
Elmendorf	1689.8	2277.8	2023.2	1239.2	836.8	1790.5	1648.4	1139.1
Tyndall	1724.0	4616.3	5204.0	410.3	157.7	1727.5	358.7	445.7
Loring	290.3	455.8	364.2	321.8	282.4	290.6	370.4	361.6
Offutt	306.6	716.1	697.3	351.1	195.0	309.8	359.3	299.0
Eielson	509.8	967.4	1894.7	551.8	169.7	558.2	531.1	233.8
Ellsworth	NA	605.5	497.6	321.8	NA	NA	477.7	NA

Offutt). The 175 percent truncation policy was examined further and the results are provided in the next section.

175 Percent Truncation Analysis

The 175 percent truncation analysis was the final analysis conducted on the data. The purpose of this analysis was to determine the percentage of recorded O & ST values which were not included in the current SBSS computation of O & ST. Current policy indicates that 80 percent of all recorded O & ST values should be used to compute O & ST, and that the remaining 20 percent of the items are outliers (values that, if included, would distort the normal O & ST average). Theoretically, then, 80 percent of O & ST values fall within 175 percent of the UMMIPS standard. The results of the truncation analysis are shown in Table 15.

Analysis Results

As indicated in Table 15 the highest percentage of actual observations included in the O & ST computation was 71 percent, which was significantly less than the standard of 80 percent. Thus, from 29 (Loring AFB) percent to 61.2 (Offutt AFB) percent of the actual O & ST observations were not used in computing an O & ST average. Additionally, the difference between the actual average and the currently used average varied from 9.2 (Loring AFB) to 39.5 (Wright-Patterson AFB) days less than the actual average O & ST.

Table 15

175 Percent Truncation Analysis

Base	Nbr O&ST Not Used	Nbr O&ST Values Used	Total Average	SBSS Average	Nbr Used %
			Priority Group 1		
Loring	27	5	33.2	10.3	10.0
Edwards	472	51	53.6	8.4	9.8
Tyndall	19	4	37.6	9.2	17.4
Wright-Patterson	536	11	69.1	9.5	2.0
Eielson	256	1550	12.4	6.9	85.8
Offutt	102	8	55.6	7.2	7.3
Maxwell	6	3	23.7	11.7	33.3
Ellsworth	60	2	50.2	13.0	3.2
Elmendorf	1341	2485	30.6	7.1	64.9

Priority Group 2

Base	Nbr O&ST Not Used	Nbr O&ST Values Used	Total Average	Cur. Used Aver.	Nbr Used %
Loring	65	17	61.1	14.1	20.7
Edwards	710	361	44.1	14.2	33.7
Tyndall	12	15	52.8	12.5	55.6
Wright-Patterson	1584	169	69.0	14.0	9.6
Eielson	556	253	64.6	16.2	31.3
Offutt	156	18	59.0	9.6	10.3
Maxwell	45	36	41.3	13.4	44.4
Ellsworth	112	5	61.9	16.6	4.3
Elmendorf	2347	1288	58.0	9.5	35.4

Table 15 (continued)

Base	Nbr O&ST Not Used	Nbr O&ST Values Used	Total Aver- age	Cur. Used Aver.	Nbr Used %
		Priority Group 3			
Loring	216	728	48	36	77.0
Edwards	3542	3348	65	34	48.6
Tyndall	96	229	53	36	70.5
Wright-Patterson	2711	5032	79	38	65.0
Eielson	1650	2323	94	65	58.5
Offutt	484	444	66	36	47.8
Maxwell	497	518	60	30	50.9
Ellsworth	71	189	51	36	72.7
Elmendorf	3026	3257	91	69	51.8

Overall

Base	Nbr O&ST Not Used	Nbr O&ST Values Used	Total Aver- age	Used Aver- age	Nbr Used %
Loring	308	748	48.6	39.4	71.0
Edwards	4724	3760	61.7	31.8	44.3
Tyndall	127	248	52.0	34.1	66.1
Wright-Patterson	4831	5212	76.7	37.2	51.9
Eielson	2462	4126	68.0	40.2	62.6
Offutt	742	470	64.0	34.5	38.8
Maxwell	548	557	58.3	28.8	50.4
Ellsworth	243	196	53.8	35.3	44.6
Elmendorf	6714	7030	65.4	36.2	51.1

In other words, some local purchase items were understocked anywhere from 9.2 to 39.5 days. Considering the number of stocked local purchase items at each base, these shortages could have a significant effect on the base mission.

The current truncation policy may adversely impact the performance of the mission by significantly reducing the O & ST used for stock leveling. However, truncation of outlying O & ST values was felt to be necessary for two reasons. First, Department of Defense (DoD) policy states that the military services will make provision for only off-the-shelf receipts (4:2). Secondly, the outlying O & ST values can and do distort the predictive powers of any O & ST forecasting model. The analysis of alternative computational methods illustrated that using the overall average O & ST (without truncation) was not significantly better and in four cases not as good a predictor of O & ST as the truncated average. The problem was the bias caused by extreme values of O & ST. Therefore, the extreme values of O & ST should be excluded from the predictive O & ST model chosen for use by the Air Force.

The purpose of the current truncation policy is also to exclude the outlying O & ST values; however, the current policy also causes the elimination of useful data. Since the original assumption behind the truncation policy was to include 80 percent of the actual O & ST values, the authors recommend the continuation of that assumption. To insure

80 percent of the values are included, the authors recommend the use of the Chebychef Theorem. The Chebychef Theorem states that for any set of measurements, ". . . a number K greater than or equal to 1, at least $(1-1/K^2)$ of the measurements will lie within K standard deviations of their mean value [10:50]." Therefore, the truncation point should be two standard deviations greater than the mean. Since only an upper limit truncation is set, this policy provides 80 of the O & ST values; 75 percent $(1-1/2^2)$ within two standard deviations plus approximately the 5 percent of the O & ST values which are less than two standard deviations less than the mean (mean minus two standard deviations).* This recommended truncation policy requires that all O & ST values be recorded to determine an overall mean and standard deviation. Once the mean and standard deviation are determined, outlying values are truncated and a new mean is computed. The new mean then would be used for predicting O & ST.

The truncation policy should coincide with the O & ST computational method. In other words, if the current SBSS method of computing O & ST is retained, the truncation

*The 5 percent figure was found to be a conservative figure. In some cases, two standard deviations below the mean was a negative number. Thus, the truncation at two standard deviations above the mean may only include 75 percent, which is still better than the current policy.

point would be that value determined by the overall mean plus two standard deviations. However, if the SBSS system segregated by type procurement is used, there would be four separate truncation points; one for each type procurement. The truncation points would all be determined the same way, only the means and standard deviations would be different for each type procurement.

Summary

The three analyses documented in this chapter were the basis for the recommended actions contained in the next chapter. The first analysis documented that the dependent variables--homogeneous grouping (NSG, NSC), type of procurement, and individual item (NSN)--affects the independent variable, O & ST. Based on these factors, four basic alternative computational methods were compared to each other to determine which method provided the smallest mean square error, and thus was the best predictor of O & ST. The second analysis indicated each alternative computational method was a better predictor of O & ST than the current system. The selection of the model for Air Force-wide use should depend on a cost/benefit analysis. The result of the final analysis documented in this chapter was that the truncation of O & ST values that exceed 175 percent of the UMMIPS standards significantly lowers the O & ST average, which can cause significant mission support

problems. A new truncation policy was proposed which insures all representative O & ST values are considered, thereby improving the predictive capability of the forecasting model.

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ORDER AND SHIP TIME COMPUTATION FOR STOCKED LOCAL PURCHASE ITEM--ETC(U)
SEP 78   D J BLAZER, C J CARTER
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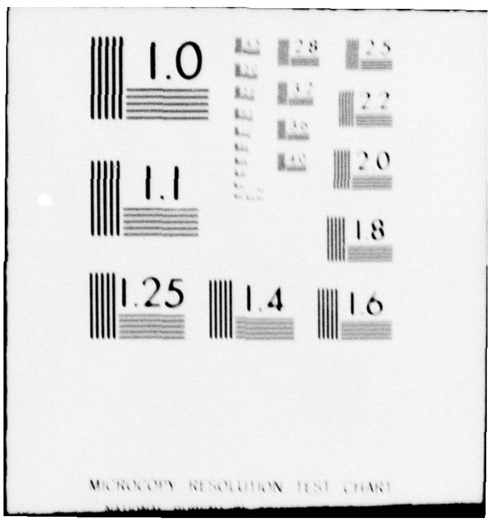
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MICROCOPY RESOLUTION TEST CHART

CHAPTER VI

RECOMMENDATIONS

This thesis sought to find a method to compute O & ST for LP items that is more accurate than the currently used Air Force system. A number of methods were analyzed, and each method was more accurate than the current Air Force system. To take advantage of these more accurate methods, three actions are recommended.

First, a cost/benefit analysis should be conducted for the weighted average for each type procurement and the moving average for each type procurement model. Both models significantly reduced the mean square error, with the weighted average model representing an 18-91 percent lower mean square error than the moving average model. However, the weighted average requires data storage for O & ST by National Stock Group, National Stock Class, National Stock Number, and type procurement; a significant increase in data storage requirements when compared to the current system. This cost must be weighed against the benefits of increased accuracy. Conversely, the moving average model requires little additional data storage requirements; only three additional routing identifier records to segregate the O & ST by the type of procurement. Thus, the model with

the highest benefit per cost ratio should be selected for Air Force-wide use. The cost/benefit analysis should be conducted by personnel from the Air Force Data Systems Design Center.

The second recommendation is to revise the truncation policy for LP items. The current policy of truncating values that exceed 175 percent of the UMMIPS standards is not performing as theoretically expected. Instead of the use of 80 percent of the actual O & ST values, only 38.8 percent (Offutt AFB) to 71 percent (Loring AFB) were being used. The use of only the lower O & ST values reduces the stockage levels from 9.2 (Loring AFB) to 39.5 (Wright-Patterson AFB) days of stock. This policy is causing significant supply support problems, as documented by personnel from the Air Staff (9), from Alaskan Air Command (20), and Edwards AFB (3:1). The solution is to insure 80 percent of the O & ST values are used in computing O & ST. Thus, recommend the truncation policy be changed to exclude all O & ST values that exceed the value determined by summing the mean and two standard deviations. This recommended policy sets a single standard that can be used at each Air Force base, and still be adaptive enough to consider the differences inherent at each base. This policy insures 80 percent of the values at each base are included, which cannot be accomplished using a constant value for truncation. Thus, each base will set their stockage policy based

on 80 percent of their observations and thereby provide a sufficient number of observations to make stockage level decisions.

The final recommendation involves the UMMIPS standards for LP items. The truncation policy described above can be implemented with or without a change in the UMMIPS standards for LP items. However, it is recommended the current standards be changed. The current standards are unrealistic, and therefore there is no attempt to adhere to them. As shown, the percentage within 175 percent of the UMMIPS standard varied from 38.8 (Offutt AFB) to 71.0 (Loring AFB). The percentage within the UMMIPS standards was less than half of those meeting the 175 percent of standard. New, realistic standards should be established, and the new standards should be set for each type of procurement. As illustrated in Chapter II (Table 3) and verified by this thesis, the amount of Procurement Administrative Lead Time (PALT) varies by type procurement (2). The standards should reflect this variability in the PALT. Thus, realistic standards based on empirical study should be established for each of the four methods of procurement. Although this thesis provides some empirical macro-level data, it does not provide an empirical data base for specific actions within the Base Procurement Office. Thus, further research should be conducted on UMMIPS standards for LP items.

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